SHEET PILE FOR FORMING BARRIER WALLS

FIELD OF THE INVENTION

[0001] The present invention relates generally to extruded structural panels fabricated of synthetic materials that are useful as pilings for driving into the earth and for forming sea walls, piers, dikes, barrier walls, retaining walls and the like. More specifically, the present invention relates to a structural panel constructed so as to minimize deterioration of the structural panel due to exposure to the elements and allow construction of a barrier wall having an exposed outer surface that is substantially free of protrusions and/or obstructions.

BACKGROUND OF THE INVENTION

[0002] Barrier walls that are formed from a plurality of elongated, vertically oriented piles typically are driven into the earth to a depth sufficient to support the panels in an upright attitude. In some cases, the piles are in the form of extruded structural panels and are formed with male and female opposed edges so that similar panels can be locked together at their adjacent side edges to form a continuous barrier wall. Because of the strength required of the panels when being driven into the earth and the strength required under load conditions, typically, the panels have been made of steel or aluminum. Frequently, steel and aluminum panels have over-sized cross sections to allow for the effects of corrosion. The additional material used in over-sizing increases the costs of the piles due to the material itself as well as the costs associated with handling the heavier piles.

[0003] In recent years, structural panels have been constructed of polyvinyl chloride and other plastics having relatively low tensile strength and high compression strength. The panels are extruded in a continuous manufacturing process, and in order to provide the strengths in the panel necessary to withstand the loads that are expected to be applied to the panels, the thicknesses of the panels have been increased over the typical thickness of similar panels formed of steel or aluminum. Further increases in thickness of the plastic

provides a diminishing return. The increased bending strength does not offset the cost of the additional plastic.

[0004] In order to produce a structural panel formed of a synthetic material that is to be used as a driven pile in the formation of a barrier wall, the panels have been formed in various strengthening cross-sectional shapes, such as V-shapes, Z-shapes, U-shapes, etc., that provide resistance to bending in response to the application of axial and/or lateral loads to the panels. Further, the panels have been constructed so as to have at their opposite edges male and female locking elements, so that the edge of one panel locks with and supports the edge of an adjacent panel.

[0005] After the first panels have been driven into place, subsequent panels can be driven into place adjacent the previously driven panels with their male and female edges locked together as they are driven, thereby forming a continuous barrier wall. The barrier wall typically is held in place with a series of horizontally placed structural members, or wales, that extend along the exposed outer surface of the barrier wall. The wales frequently are held in place with a plurality of tie rods. The tie rods extend through the wale, the barrier wall, and the soil disposed behind the barrier wall, and have one end secured to the wale and another end which is secured to a force abutter. Typically, the force abutter is a reinforced cement wall disposed a desired distance behind the barrier wall such that adequate force is exerted from the force abutter through the tie rods on the barrier wall, thereby maintaining the barrier wall in the desired position. As constructed, these barrier walls have a number of obstructions, such as wales, tie rods, etc., present on the exposed outer surface of the barrier wall. These obstructions are subject to damage from, and may cause damage to, boats, barges, and like craft that frequently operate near and are secured to such barrier walls.

[0006] Therefore, there is a need for improved extruded structural members which address these and other shortcomings of the prior art.

SUMMARY OF THE INVENTION

[0007] Briefly described, the present invention relates to a structural panel for forming sea walls, barrier walls, and the like, fabricated of synthetic resin material for driving into

soils. The structural panel is elongated and of constant size and shape along its length, and is characterized by having been extruded lengthwise. The structural panel includes, in cross section, a central wall section having an inner surface, an outer surface, a first side wall section, and a second side wall section. A male locking element is disposed on and extends laterally from the first side wall section while a female locking element is disposed on and extends laterally from the second side wall section, the female locking element being configured to slidably receive and retain the male locking element of a duplicate panel. First and a second strengthening flanges are integrally formed on the inner surface, the first and second strengthening flanges being both substantially perpendicular to the central wall section and substantially parallel to each other. The first and second strengthening flanges extend along the length of the structural panel.

[0008] The present invention also relates to a driven wall structure for retaining soil, the wall including a plurality of structural panels. Each of the panels includes, in cross section, a central wall section having an inner surface, an outer surface, a first side wall section, and a second side wall section. A male locking element is disposed on and extends laterally from the first side wall section while a female locking element is disposed on and extends laterally from the second side wall section. The female locking element is configured to slidably receive and retain the male locking element. At least one strengthening flange is integrally formed on the inner surface, the strengthening flange being substantially perpendicular to the central wall section and extending along the length of the structural panel. The plurality of structural panels is slidably connected by the male locking elements and the female locking elements of adjacent structural panels. A plurality of anchor bars extend through the strengthening flanges such that the anchor bars are substantially parallel to both the wall structure and other of the anchor bars. A plurality of anchor sheets is securely attached to the anchor bars, each anchor sheet extending outwardly from the wall structure. Soil is disposed about the anchor sheets such that the weight of the soil retains the wall structure in a desired position.

[0009] The present invention also provides a method of installing a driven wall structure for retaining soils, the wall including a means for retaining the wall in a fixed position relative to the soils, a series of elongated structural panels each having an upper end

portion and a lower end portion, opposed inner and outer surfaces, elongated opposed edges shaped for slidably connecting to the edge of an adjacent structural panel, and at least one strengthening flange extending from the inner surface. The method includes the steps of: joining one of the opposed edges of each structural panel to one of the opposed edges of a previously driven structural panel and driving the lower end portion of each structural panel into the soil, thereby forming the wall structure; attaching the means for retaining to the strengthening flanges of the structural panels; and disposing soil both about the means for retaining and adjacent the inner surfaces of the structural panels.

[0010] Other objects, features and advantages of the present invention will become apparent upon reading the following specification, when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0011] Many aspects of the invention can be better understood with reference to the following drawings. The components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present invention. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views.

[0012] FIG. 1 is a perspective fragmentary view of a barrier wall constructed in accordance with an embodiment of the present invention, used as a sea wall.

[0013] FIG. 2 illustrates a cross-sectional view of a preferred embodiment of a structural panel of the present invention.

[0014] FIG. 3 is a perspective view of the structural panel with portions broken away to illustrate the strengthening member and the surrounding extruded coating.

[0015] FIG. 4 is a perspective illustration of adjacent structural panels with their locking elements attached and an anchor system extending rearwardly therefrom.

[0016] FIGs. 5A and 5B illustrate partially cut-away, side elevations of the barrier wall of the present invention, as shown in FIG. 1, taken along line V-V, illustrating various embodiments of anchor systems.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] Reference will now be made in detail to the description of the invention as illustrated in the drawings. While the invention will be described in connection with these drawings, there is no intent to limit it to the embodiment or embodiments disclosed therein. On the contrary, the intent is to cover all alternatives, modifications and equivalents included within the spirit and scope of the invention as defined by the appended claims.

[0018] In particular, FIG. 1 illustrates a barrier wall, in the form of a sea wall 10, constructed of structural panels 20 according to the present invention. Typically, the sea wall 10 forms a retainer for the soil 12 on the backside of the structural panels 20, with water 14 at the front surface. The panels 20, as shown in FIGs. 5A and 5B, extend vertically with lower ends received in the subsoil below the lower level of the body of water 14. The panels 20 are joined in side edge to side edge relation and maintained in the desired position by an anchor system 68.

[0019] FIG. 2 illustrates one of the structural panels 20. Each structural panel is formed of a plastic, such as polyvinyl chloride, polypropylene, polyethylene or other suitable synthetic or polymer material. Preferably, the materials chosen are strong and highly resistant to adverse weather conditions, and include properties that adequately resist abrasion from soils, resist deterioration due to ultra-violet radiation, and can withstand the bending and compressive forces normally encountered under conditions such as being driven into the ground.

[0020] The structural panels 20 are extruded lengthwise so as to form a constant, uniform cross-section from end-to-end. In a preferred embodiment, each panel 20 includes in cross-section a central wall section 22, side wall sections 21 and 23 on opposite sides of and coextensive with central wall section 22, and a pair of first and second strengthening flanges 30, 32 extending from the inner surface 26 of the structural panel 20. The strengthening flanges 30, 32 are substantially perpendicular to the central wall section 22 and extend lengthwise along the structural panel 20. Preferably, each strengthening flange 30, 32 includes at its distal edge 31, 33, oppositely facing secondary flanges 34,

35, respectively, such that the secondary flanges 34, 35 are substantially perpendicular to their respective strengthening flange 30, 32.

[0021] A male locking element 27 and a female locking element 28 are disposed at opposite edges of the side wall sections 21 and 23. Other configurations are possible for the male and female locking elements 27 and 28. However, typically, the female locking element 28 comprises a channel configured to slidably receive the male locking element 27 that consists of a protrusion. Preferably, the outer surface 24a, 24b and 24c of the central wall section 22 and side wall sections 21 and 23 are substantially co-planar such that when the structural panels are assembled in inner locking side edge to side edge relationship to form a barrier wall 10 the barrier wall will have a similarly substantially planar outer surface.

[0022] In the preferred embodiment shown in FIG. 2, an internal strengthening member 50, as indicated by the dashed line, may be comprised of steel, galvanized steel, aluminum or like materials, and has portions that extend from the first strengthening flange 30 through the central wall section 22 and into the second strengthening flange 32. Note however, embodiments are envisioned that include only one strengthening flange 30, 32 and a strengthening member 50 that extends at least partially into both the strengthening flange 30, 32 and the central wall section 22. The strengthening member 50 is encased in the material of the structural panel so that the strengthening member 50 is shielded from contact with the outside environment.

[0023] FIG. 3 shows a perspective view of the structural panel 20 shown in FIG. 2, with portions of the extruded material removed to better show the strengthening member 50. Preferably, the strengthening member 50 is constructed of an expanded metal, such as steel. The expanded metal is of known construction, that includes sheet metal formed with an array of parallel, longitudinally offset slits that have been opened by lateral expansion of the sheet to form perforations in the sheet. However, the strengthening member 50 may also be formed from a solid sheet of metal, a solid sheet of fiberglass, or a perforated sheet of fiberglass.

[0024] As shown in FIG. 3, each strengthening flanges 30 and 32 include a plurality of retention apertures 36 that are disposed along the length of each of the strengthening

flanges 30, 32. Preferably, the retention apertures 36 in the first strengthening flange 30 are positioned such that they coincide with the retention apertures 36 formed in the second strengthening flange 32.

[0025] FIG. 4 illustrates a pair of structural panels 20a, 20b positioned in side-by-side interlocking relationship, with the female locking element 28 of structural panel 20b telescopically engaged with the male locking element 27 of structural panel 20a. Typically, when a structural panel, such as 20b, is to be driven into the earth at the construction site, the structural panel 20b is positioned higher and adjacent a previously installed structural panel 20a with the female locking element 28 positioned above the male locking element 27 of the previously installed adjacent structural panel 20a. The structural panel 20b being installed is then moved downwardly so that the female locking element 28 guides itself along the length of the male locking element 27 of the adjacent previously installed structural panel 20a, and the structural panel 20b is progressively moved downwardly by driving, vibration, gravity, or other external forces, until the upper ends of the structural panels 20a, 20b become located at approximately the desired height. If necessary, the upper ends of the structural panels 20a, 20b that cannot reach the desired height can be cut away. In the preferred embodiment, the first and second strengthening flanges 30, 32 assist in driving operations in that the required external force applied to the upper end of the structural panel is distributed over a larger surface area than just that of the central wall section 22 (FIG. 2). As well, the strengthening member 50 assists in transmitting those external forces vertically through the structural panels and into the soils 12 underneath.

[0026] After adjacent structural panels 20a, 20b have been driven to the desired height, an anchor system 68 can be installed. The anchor system 68 shown in FIG. 4 includes a plurality of anchor bars 60a-c and anchor sheets 62a-c. Individual anchor bars 60a-c and anchor sheets 62a-c have been given supplemental letter designations for ease of description only. Ideally, each structural panel 20a, 20b is driven to the desired height. As such, the retention apertures 36 disposed in the strengthening flanges 30 and 32 of both structural panels 20a, 20b will be axially aligned. So aligned, each anchor bar 60a-c can be passed through its respective set of retention apertures 36 located in the various

structural panels 20a, 20b. This is most clearly seen in that anchor bar 60c passes through the retention apertures 36 disposed in the adjacent structural panels 20a, 20b. However, as previously noted, it may be necessary to remove a top portion of one of the structural panels 20a, 20b, in which case the retention apertures 36 of the adjacent structural panels 20a, 20b may not be axially aligned. In this case, it is possible for the installer to create auxiliary retention apertures 36 on the job site to allow passage of the anchor bars 60a-c. In the preferred embodiment shown, providing auxiliary retention apertures 36 is facilitated in that the strengthening member 50 is constructed of expanded metal having a plurality of perforations 52 (FIG. 3). Ideally, the perforations 52 of the expanded metal anchor sheet allow auxiliary retention apertures 36 to be drilled therethrough, without having to drill through the metal of the strengthening member. However, even when the strengthening member 50 is comprised of sheet metal, auxiliary retention apertures 36 may be constructed. Also, the retention apertures 36 usually are of greater breadth than the anchor bars 60 so that perfect alignment of the retention apertures 36 may not be necessary. Also, since each panel has retention apertures 36 in both of its strengthening flanges 30, 32, short anchor bars 60 can be used to hold the anchor sheet 62 without the anchor bars extending to adjacent panels.

[0027] Anchor sheets 62a-c are securely connected to the plurality of anchor bars 60a-c. Note, each anchor sheet 62a-c may be secured to its respective anchor bar 60a-c either prior to, during, or after installation of the anchor bars 60a-c into the structural panels 20a, 20b. Generally, the anchor sheets 62a-c are substantially flat sheets which define a plurality of large openings or apertures. During construction of the barrier wall 10 (FIG. 5A) back fill soil 12 covers the anchor sheet 62a-c. Rocks, stones and soil in the back fill occupy apertures in the sheets. These materials mechanically connect the anchor sheets 62a-c to the soil mass 12, and thereby secure the barrier wall 10 to the soil mass 12. Thus, the retention apertures 36 and anchor bars 60 function as connection means for connecting the anchor sheets 62 to the structural panel. Other connection means can be used, such as clamps that extend from the anchor bars to the secondary flanges 34, 35.

[0028] Referring now to FIG. 5A, after the structural panel 20 has been driven to the desired depth, anchor bar 60a and anchor sheet 62a are installed. Anchor sheet 62a is

extended rearwardly and allowed to rest on top of the existing soil. Soil is then placed on top of anchor sheet 62a up to approximately the level at which the next anchor bar 60b and anchor sheet 62b will be installed. After installation of anchor bar 60b and anchor sheet 62b, anchor sheet 62b is allowed to rest on the existing soil. Soil is once again disposed on top of anchor sheet 62b, thereby maintaining anchor sheet 62b in position. This process is repeated until the desired number of anchor bars 60 and anchor sheets 62 have been installed. The plurality of anchor sheets 62 exert a retention force on the barrier wall 10. Embodiments of barrier walls 10 are envisioned having as few as one anchor bar 60 and one anchor sheet 62. However, typical barrier walls 10 include pluralities of each.

[0029] Referring now to FIG. 5B, another embodiment of an anchor system 68 is shown. An anchor wall 66 of poured reinforced concrete is placed behind the barrier wall 10 and extends generally parallel to the wall 10. Anchor members 64, typically tie rods, are connected at one end to a reinforcing rod 67 embedded in the anchor wall 66 and at the opposing end to the strengthening flange 30 of the structural panel 20, thereby holding the barrier wall 10 in the desired position. A plurality of anchor members 64 extend from the anchor wall 66 to the barrier wall 10 at intervals along the length of the wall 10. Following installation, the space between the barrier wall 10 and anchor wall 66 is filled with soil 12.

[0030] Although preferred embodiments of the invention have been disclosed in detail herein, it will be obvious to those skilled in the art that variations and modifications of the disclosed embodiment can be made without departing from the spirit and scope of the invention as set forth in the following claims.